Leaf & Yard Waste Diversion Targets in Alberta:

A Benefit Cost Analysis

April 2012

Alberta

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Executive Summary

Alberta Environment and Sustainable Resource Development is examining options to decrease disposal of leaf and yard waste in landfills. To this end, Alberta Environment and Sustainable Resource Development staff organized the Leaf & Yard Waste Diversion Committee to develop a Leaf and Yard Waste Diversion Strategy. This draft Strategy recommends various options to divert leaf and yard waste to beneficial use, and includes a recommendation to compost this material. A Feasibility Study[1] of the Strategy was conducted. It includes recommended diversion rates and potential infrastructure costs for establishing centralized composting facilities for processing the diverted material. This report evaluates the benefits and costs of composting leaf and yard waste as compared to landfill disposal of this waste. Current generation and amount being composted and recommended diversion rates data from the Feasibility Study was used for this benefit cost analysis.

Modest and aggressive diversion targets[2] were compiled for each region of Alberta. The overall diversion targets for the regions differ widely depending on the percentage of small, medium, and large urban centres found in the region. Large urban centres are designated a higher diversion target than small centres. Rural populations are not assigned a diversion target because it is assumed these residents are less likely to participate in centralized leaf and yard waste diversion programs. No target was recommended for leaf and yard waste from industrial, commercial, and institutional (ICI) sources.

The scale of analysis for this report is seven regions of Alberta, as defined in the Government of Alberta's Land Use Framework.[3]

About 500,000 tonnes of leaf and yard waste is generated from both residential and ICI sources. This represents 11% of the municipal solid waste (MSW) stream collected annually in Alberta.[4] As Alberta's population increases in the next 30 years, the amount of leaf and yard waste is expected to increase by 50% to approximately 750,000 tonnes annually. The two main options examined to manage leaf and yard waste are composting and landfilling. Currently, approximately 25% of leaf and yard waste is composted with the remainder being landfilled. Composting as an alternative to disposal at a landfill has garnered significant interest in the waste management field, motivated in part by the desire to minimize the amount of waste entering landfills and to create a useful soil amendment.

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[1] CH2M Hill, "Leaf and Yard Waste Diversion Strategy Feasibility Study," written for Alberta Environment. 2010

[2] More details about diversion rates can be found in Tables ES 1 and ES 2 at the end of the Executive Summary.

[3] Government of Alberta, "Land-use Framework," 2011 http://www.landuse.alberta.ca/ (accessed May 6, 2011).

[4] CH2M Hill, "Leaf and Yard Waste Diversion Strategy Feasibility Study," written for Alberta Environment. 2010

Data were assembled on amounts of leaf and yard waste collected, composting and landfill infrastructure, and the costs and benefits of composting compared to disposal in landfill. The current level of composting was treated as the baseline, that is, this study evaluates the incremental benefits and costs resulting from meeting the proposed diversion targets. This report examines the following effects: change in greenhouse emissions from 2010 composting levels, landfill disposal costs, compost costs, and value of compost produced. Additional social, health and environmental effects are not examined as these effects are likely site specific (e.g. impact on property values and potentially unpleasant odour, noise and traffic issues associated with a waste management facility). Nevertheless, the potential for composting facilities and landfills to create effects beyond the site of operation (externalities) is acknowledged.

Table ES1 shows that with the modest diversion target, the quantified annual net benefit is expected to range from $3.0 to $3.8 million in 2010 to $5.3 to $6.4 million by 2040. Relative to current leaf and yard waste management practices, the diversion targets are expected to reduce greenhouse gas emissions by 20 % annually by 2040.

Table ES2 shows that with the aggressive diversion target, the quantified annual net benefit is expected to range from $5.7 to $7.0 million in 2010 to $11.5 to $13.9 million by 2040. Relative to current leaf and yard waste management practices, the diversion targets are expected to reduce greenhouse gas emissions by about 45 % annually.

Note that because some composting already occurs in the province, establishing diversion targets may not yield additional diversion in some of the land use regions. For example, the Red Deer region is expected to meet both the modest and aggressive diversion targets under the current rate of composting for the duration of the forecast period. The North Saskatchewan region currently accounts for 80% of leaf and yard waste composted in the province. With current level of composting, the North Saskatchewan region is expected to meet the modest diversion target for the duration of the forecast period

One limitation of this report is its focus solely on onsite leaf and yard waste management cost due to scope and data availability. Offsite costs (e.g. collection and transportation costs) were assumed to not vary among the two disposal options (i.e. no difference in cost to collect and transport a tonne of leaf and yard waste to a compost facility or to a landfill). However, collection and transportation represents a large proportion of waste management expenditure. Statistics Canada (2006) reports that 45% of the total cost of waste management is for collection and transportation. In fact, transportation is the single largest category of costs for waste management in Alberta. Although this report recognizes the transportation costs by assuming onsite management (e.g. grasscycling) of leaf and yard waste for communities with annual collection less than 50 tonnes, further detailed study on these costs as well as unaccounted benefits are warranted. Further study that examines collection and transportation costs may result in different costs and benefits.

Table ES 1 Net Benefit of Increasing Centralized Composting of Leaf and Yard Waste, to Meet Modest Diversion Target, Presented by Regions (Reduction in GHG emissions in metric tonnes of CO_2 equivalents)

	2010	**2020**	**2040**
Lower Athabasca	Currently meets diversion target	Currently meets diversion target	$97,300 – 131,000 (5,352)
Lower Peace	$ -1,300 – -865 (68)	$ -1,350 – -900 (71)	$ -1,500 – -1,000 (78)
North Saskatchewan	Currently meets diversion target	Currently meets diversion target	Currently meets diversion target
Red Deer	Currently meets diversion target	Currently meets diversion target	Currently meets diversion target
South Saskatchewan	$3.1– 3.8 M (107,888)	$3.7 – 4.5 M (127,989)	$5.2 – 6.3 M (178,554)
Upper Athabasca	Currently meets diversion target	Currently meets diversion target	Currently meets diversion target
Upper Peace	$6,400 – 15,000 (1,127)	$7,100 – 17,600 (1,319)	$8,900 – 22,200 (1,777)
Total	$3.1 – 3.8 M (109,083)	$4.4 – 3.6 M (129,379)	$5.3– 6.4 M (185,767)

Net benefit is calculated as: Avoided Cost – Composting Cost + Value of Additional Compost

Modest Diversion Targets

- Rural residents: no target established
- Small urban centres: 15%
- Medium urban centres: 15%
- Metro and large urban centres: 50%
- Participation by Industrial, commercial, and institutional generators: minimal

Table ES 2 Annual Net Benefit to Increase Centralized Composting of Leaf and Yard Waste to Meet Aggressive Diversion Target, Presented by Region (Reduction in GHG emissions in metric tonnes of CO2 equivalents)

	2010	**2020**	**2040**
Lower Athabasca	None – meets diversion target	$4,600 – 12,000 (1,213)	$294,000 – 376,000 (13,165)
Lower Peace	$-8,300 - -5,600 (437)	$ -8,700 – - 5,800 (459)	$ -9,600 - -6,500 (507)
North Saskatchewan	$0.4 – 0.5 M (18,149)	$1.4 – 1.7 M (36,935)	$2.5 – 3.0 M (82,332)
Red Deer	Currently meets diversion target	Currently meets diversion target	Currently meets diversion target
South Saskatchewan	$5.3 – 6.5 M (185,711)	$6.3 – 7.6 M (217,959)	8.6 – 10.5 M (299,049)
Upper Athabasca	$7,000 – 18,500 (1,847)	$7,500 – 19,600 (1,963)	$8,500 – 22,100 (2,213)
Upper Peace	$10,200 – 26,700 (2,679)	$11,400 – 29,800 (2,987)	$14,200 – 37,200 (3,721)
Total	$5.7 – 7.0 M (208,823)	$7.7 - 9.3 M (261,516)	$11.5 - 13.9 M (400,987)

Net benefit is calculated as: Avoided Cost – Composting Cost + Value of Additional Compost

Aggressive Diversion Targets

- Rural residents: no target established
- Small urban centres: 40%
- Medium urban centres: 60%
- Metro and large urban centres: 80%
- Participation by Industrial, commercial, and institutional generators: no target specified

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1. Background

Provincially, approximately 500,000 tonnes of leaf and yard waste is generated from both residential and ICI sources. This represents 11 % of the municipal solid waste (MSW) stream generated annually in Alberta[5]. Currently, about 25 % of leaf and yard waste collected as part of the MSW stream in Alberta is composted and the remainder landfilled. Alberta Environment and Sustainable Resource Development's Leaf and Yard Waste Diversion Strategy (Strategy) recommends policy tools and options to divert leaf and yard waste away to beneficial use, such as composting. A Feasibility Study[6] of the Strategy was conducted. It includes recommended diversion rates and potential infrastructure costs for establishing centralized composting facilities for processing the diverted material. This report evaluates the benefits and costs of leaf and yard waste composting that result from the recommended diversion rates. These benefits and costs are compared to landfill disposal of leaf and yard waste.

Composting organics as an alternative to disposal in a landfill has garnered significant interest in the waste management field, motivated in part by the desire to minimize the amount of material disposed. Given that approximately 40 % of MSW contains organics (e.g. leaf and yard waste, vegetable processing wastes and table scraps) are amenable to composting, this is a feasible management alternative to landfilling. Diverting more organics away from landfills will help communities meet waste reduction targets and extend the life of their landfills. In Alberta, there are over 60 compost facilities processing over 530,000 t/y of organics and it is estimated a fifth (125,000 tonnes[7]) of their capacity is used for processing leaf and yard waste. Thus, it is estimated that the majority of leaf and yard waste collected as part of the MSW is landfilled.

The scale of this analysis is regional, and uses the Land Use Framework regions (Figure 1-1). This analysis is not intended to assess the merits of the two options at an individual municipality or facility scale.

A Note on Full Cost Analysis and Benefit Cost Analysis

There is no universally accepted common definition of full cost analysis. While some view full cost analysis as strictly one that accounts for direct monetary outlays others view full cost more expansively which includes direct monetary outlays as well as social and environmental effects of a decision (similar to benefit cost analysis). It is beyond the scope of this paper to reconcile these differing views. Alberta Environment and Sustainable Resource Development defines full cost as "the total of real, definable and measurable costs, both direct and indirect and from all

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5 CH2M Hill, "Leaf and Yard Waste Diversion Strategy Feasibility Study," written for Alberta Environment. 2010.

6 CH2M Hill, "Leaf and Yard Waste Diversion Strategy Feasibility Study," written for Alberta Environment. 2010.

7 Adjusted for reduced processing capacity in the Red Deer Region with closure of CorCan facility and reduced intake by Olds College. This report uses 8,880 tonnes for the Red Deer Region compared to 13,840 used by CH2M Hill (2010).

sources, incurred or attributed to the particular project or system in question, when taken together with all additional considerations that are not measurable in monetary terms but may influence decisions or perceptions relating to the project or system." (Alberta Environment, 1995, p.6). Alberta Environment and Sustainable Resource Development's definition of full cost is similar to benefit cost analysis in that monetary costs as well as social, health and environmental effects are included. Therefore, this report uses the benefit cost analysis approach.

This report examines the following effects: change in greenhouse emissions from 2010 composting levels, landfill disposal costs, compost costs, and value of compost produced. Additional social, health and environmental effects are not examined as these effects are likely site specific (e.g. impact on property values and unpleasantness from potential odour, noise and traffic issues associated with a waste management facility) and this report examines management options at an aggregate, not site specific scale. Nevertheless, the potential for a waste management facility to create effects beyond the site of operation (externalities) is acknowledged.

Figure 1-1 Land Use Framework Map of Regions

2. Data and Methods

This study examines the incremental costs and benefits of additional composting resulting from meeting the diversion targets recommended in the Feasibility Study. About 125,000 tonnes of leaf and yard waste is currently composted annually, and this value used as the baseline for the analysis. It is assumed that the current composting capacity will remain unchanged over the forecast period. The data used in this study, unless stated otherwise, are derived from the Feasibility Study conducted by CH2M Hill (2010)[8].

2.1 Collection and Current Infrastructure

1. All Alberta communities (cities, towns, municipal districts, etc.) were put in a database to calculate an estimate of their leaf and yard waste collection for both residential and industrial, commercial, and institutional (ICI) sources. The communities were assigned municipal units[9] based on their population in 2008 and Land Use Regions based on their location.[10]

e.g. Cold Lake

- Population: 12,860
- Municipal Unit: large urban
- Land Use Region: Lower Athabasca

2. For each community a population forecast to 2040 was prepared, using 2008 as the base year. Municipal unit specific population forecast and/or growth rate, where available, was used for the forecast. Where specific growth rate was not available historic growth rate (1990 – 2008) was calculated using Municipal Affairs population data.

3. Per capita estimates of leaf and yard waste collection associated with each type of community was calculated. This calculation was based on the generation rates used in the Feasibility Study. This per capita estimate was multiplied by the population to derive the total leaf and yard waste that was expected to be collected from each community.

4. Two scenarios for diverting leaf and yard waste from landfilling were examined: modest and aggressive diversion targets (Table 2-1). The amount of leaf and yard waste to be diverted by each community was determined by its designated municipal unit and associated diversion target. Large urban centres are designated a higher diversion target than small centres. Rural populations are not assigned a diversion target because it is assumed these residents are less

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[8] CH2M Hill, "Leaf and Yard Waste Diversion Strategy Feasibility Study," written for Alberta Environment. 2010.

[9] Municipal units refers to metro and large urban (population over 10,000), medium urban (population from 2500 to 10,000), small urban (population up to 2,500) and rural areas (counties, municipal districts).

[10] There were 409 municipal units, each of these units were categorized into respective land use framework region. For example, Edmonton belongs in the North Saskatchewan region, Lethbridge belongs in the South Saskatchewan region.

likely to participate in centralized leaf and yard waste diversion programs. Note that the overall diversion for each region is an aggregation of municipality specific diversion target for that region. Thus, overall diversions differ for each region since the diversion depends on the percentage of small, medium, and large urban centres found in each region.

e.g. Cold Lake

- Estimated collection of leaf and yard waste from residential sources: 604 t/y
- Estimated collection of leaf and yard waste from ICI sources: 787 t/y
- Modest diversion target is 50% of residential LYW, no target for ICI:
- 50% of 604 t/y = 304 t/y

Table 2-1 Leaf and yard waste diversion targets from Feasibility Study

Municipal unit	**Modest Diversion Target (Case 1)**	**Aggressive Diversion Target (Case 2)**
Rural residents	No target established	No target established
Small urban centres (population between up to 2,500)	15%	40%
Medium urban centres (population up to 10,000)	15%	60%
Metro and large urban centres (population greater than 10,000)[11]	50%	80%
Participation by industrial, commercial and institutional (ICI) generators	Minimal	Actively encouraged (but diversion target not specified)

5. Suggested waste flows and proposed locations for composting facilities were needed to understand where diverted leaf and yard waste could be processed. The designated composting facility for leaf and yard waste collected from each community was determined by examining a map of Alberta and proposing locations for processing the material; opportunities to aggregate material at central facilities were balanced by estimated transportation distances from generators to facilities.[12] Some facilities could receive waste from a single community while other facilities could serve several communities, including from outside their land use region. For the purpose of this analysis, waste movement outside of its land use region is not expected

[11] CH2M Hill (2010) assigns same diversion target for metro and large urban centres.

[12] Proposed locations for material processing were based on CH2M Hill (2010).

to significantly alter the results. It was also assumed communities with annual collection of leaf and yard waste greater than 50 tonnes would divert this material to a centralized composting facility; communities collecting less than 50 tonnes would focus on grasscycling or backyard composting instead.

6. Collection resulting from the diversion targets was compared with current infrastructure capacity.

2.2 Costs

Compost and landfill cost data were obtained from existing studies. The costs are listed in 2010 dollars. For both compost and landfill, collection and transportation costs are excluded under the assumption that these costs do not vary given that most compost facilities tend to be co-located within a landfill. Thus, only on-site costs are analyzed.

The total annual costs[13] per tonne of compost were calculated for small, medium, large and very large facilities (Table 2-2). These costs were estimated to be $75 for small, $45 for medium, $21 for large and $19 for a very large facility.

[13] A full description of the assumptions used to calculate operating costs per tonne of compost are found in" Section 5: L&YW Composting Facility Conceptual Designs" of the "Leaf and Yard Waste Diversion Strategy Feasibility Study", CH2M Hill, (2010).

Table 2-2 Compost facility costs[14]

Facility description	Small (500 tonne/yr)	Medium (4,000 tonne/yr)	Large (15,000 tonne/yr)	Very Large (250,000 tonne/yr)
Technology used	Windrow	Windrow	Windrow	Aerated static pile
Annual throughput (tonne)	500	4,000	15,000	145,000
Capital cost ($)	122,200	1,000,000	1,690,000	16,011,451
Operation cost ($/tonne)	55	25	12	10
Amortized annual capital cost ($)	9,790	80,243	135,610	1,284,800
Amortized annual capital cost/tonne	32	32	15	11
Annual capital and operating cost/tonne	75	45	21	19

A tipping fee at a landfill can be expected to reflect the cost of disposal and management of waste according to regulatory requirements. Tipping fees for landfills in Alberta were reported in the Feasibility Study, and they varied widely. They ranged from less than $20 to about $141 per tonne, with an average fee of $59 per tonne. An examination of how landfill fees in Alberta vary according to capital and operation costs was outside the scope of the Feasibility Study, so the reported tipping fees were not used as a proxy for landfill costs.

Compost facility development and operation costs were provided in the Feasibility Study and used for this analysis. In order to make a valid comparison between landfilling and composting, the data for landfill costs was derived from the Municipal Solid Waste Option[15]. This report provides a detailed breakdown of costs associated with varying sizes of landfills. Some data in that report were adjusted including: converting cost from 2006 currency year to 2010 currency year using Statistics Canada industrial construction cost index for seven census metropolitan areas; removing pre-development costs (site selection, land acquisition, regulatory approval

[14] CH2M Hill (2010) uses non-amortized value, that is, interest cost of capital is not included. This report assumes 5% interest rate and facility life of 20 years. Therefore, the annual capital and operating costs differ from CH2M Hill (2010). There may be some post closure costs (e.g. decommissioning, land reclamation), however, these costs are likely minor not assumed not to affect the overall cost. Therefore, post closure costs are not included for compost facilities.

[15] "Municipal Solid Waste (MSW) Options: Integrating Organics Management and Residual Treatment/Disposal," Written for Municipal Waste Integration Network / Recycling Council of Alberta. 2006.

cost) since these are likely to be site specific costs; and removal of landfill gas capture as this is not currently a common practice in Alberta. Data for cell excavation and base preparation was also adjusted. The original value of $100/m2 was considered high based on literature review and professional judgment therefore, that value was replaced with $7/m2; this value is derived from the excavation cost listed in the current landfill financial security calculation guideline developed by Alberta Environment and Sustainable Resource Development. Table 2-3 lists the landfill disposal cost of municipal solid waste. The annual cost per tonne is estimated to range from $43 to $63. An itemized list of landfill costs can be found in Appendix A.

Table 2-3 Landfill disposal cost derived from Municipal Solid Waste Option (2006)[16]

Landfill Description	Small landfill	Medium Landfill	Large Landfill
Annual through put (tonne)	14,679	57,521	146,790
Capital cost ($)	$15,765,895	$60,029,839	$113,061,614
Amortized annual capital cost ($/tonne)	$26	$36	$27
Operation cost ($/tonne)	$16	$21	$21
Post closure ($/tonne)	$1.22	$4.89	$4.08
Annual capital, operating, post closure ($/tonne)[17]	$43	$62	$52

2.3 Benefits

Three categories of benefits are quantified: change in greenhouse gas emissions[18] from 2010 composting levels, value of compost, and avoided landfill costs and listed in 2010 dollars.

[16] Municipal Solid Waste Option (2006) did not provide estimate for landfill cost greater than annual through put of 146,970. For greater throughput, it was assumed that costs would be similar to 146,970 tonne landfill cost.

[17] Annual capital and operating cost per tonne were derived with assumption of 5% interest rate and facility life of 20 years. Post closure liability was calculated using 5% interest rate and 30 year time period.

[18] Greenhouse gas reduction was calculated using the procedure outlined in CH2M Hill (2010) which is based on the Alberta Environment (2008) Guidance - Quantification Protocol for Aerobic Composting Projects.

1. For every tonne of leaf and yard waste, landfilling is expected to generate about 1.47 tonnes while composting is expected to generate about 0.18 tonnes of greenhouse gases. Greenhouse gases are quantified in metric tonne carbon dioxide equivalents (t CO_2 eq). There is considerable debate surrounding the appropriate valuation method and the price associated with greenhouse gas emissions; therefore, monetary quantification of these emissions is not undertaken. However, it is generally acknowledged that reduction in greenhouse gas emissions is beneficial and a desirable policy objective.
2. Compost has end use application in landscaping, gardening as well as amendments to soil substrates. It is assumed that the compost produced can be delivered to a variety of uses such potting mixes for greenhouses and application to agricultural land, and will range in value from $14 to $30 per tonne.
3. Each tonne of leaf and yard waste collected is disposed either in a landfill or composted. The difference in cost between landfill and composting is calculated as the avoided landfill cost.

2.4 Net Benefit

Net benefit is calculated as the benefit (avoided landfill cost + compost value) - cost (composting cost).

A Note of Benefit Cost Results: Benefit cost analysis was conducted only in cases when diversion targets resulted in additional diversion than business as usual (BAU[19]). In some cases the analysis was conducted for the entire forecast period (2010- 2040). However, of that analysis only the results from specific years: 2010, 2020 and 2040 are presented to facilitate easier comparison of results among the regions.

2.5 Unaccounted Costs and Benefits

The report has previously noted the rationale for several benefit categories that were not assessed due to the scope of the study. Some costs have also not been accounted; most notably, the cost of collection and transportation, under the assumption that costs do not vary given that most compost facilities tend to be co-located within a landfill. Nonetheless, collection and transportation is the largest category of waste management expenditure. In 2006, collection and transportation represented about 45% of the total cost (Statistics Canada, 2006). This study recognizes the transportation costs by assuming onsite management (e.g. grasscycling) of leaf and yard waste for annual collection less than 50 tonnes. Further detailed study that examines these unaccounted benefits and costs is warranted.

[19] BAU refers to 'business as usual' - no increase in levels of leaf and yard waste composting from 2010 levels.

3. Alberta Overview of Municipal Solid Waste Stream

3.1 Waste Collection and Management

The municipal solid waste stream is comprised of two main sources: residential (household garbage, leaf and yard waste), and non – residential (industrial, commercial, and institutional). Residential sources make up between 10 % to 40 % of the municipal solid waste stream, depending on the size of a community (EBA, 2007). Larger communities tend to have a higher proportion of municipal waste stream that is from residential sources.

About 4.3 million tonnes[20] of municipal sold waste was collected in Alberta in 2008 with the South Saskatchewan (42%), the North Saskatchewan (39%) and the Red Deer (8%) regions collectively accounting for about 90 % of that total waste. These numbers reflect the fact that these regions have the majority of the population and economic activities and generate most of the waste.

As Alberta's population grows, the amount of municipal solid waste that is collected can be expected to increase. Compared to today, Alberta's population is expected to be 1.5 times greater by 2040. This increased population will bring the total amount of municipal solid waste stream being collected to about 6.5 million tonnes annually, based on 2008 disposal data. Lower Athabasca will record the fastest growth with population tripling by 2040; however, North and South Saskatchewan together will continue to account for about 80 % of Alberta's population.

Disposal in landfills is the primary approach to managing municipal solid waste. Using the generation numbers and estimated diversion rates derived in this study, it is estimated that 70% (3.1 million tonnes) of the waste is currently landfilled in the province. In 2008, the per capita basis the calculated value is about 900 kg/person which is similar to Statistics Canada per capita estimate of about 968 kg/person. The South Saskatchewan (47%), the North Saskatchewan (30%) and the Red Deer (9%) regions collectively accounting for about 85% of that all waste that is being landfilled. By 2020, the proportion of municipal solid waste being landfilled is expected to decline to about 40 % as greater numbers of municipalities implement expanded diversion programs. This calculation of greater diversion is based on taking into account publicly stated diversion target and goals

Figure 3-1 shows that in 2010 about 500,000 tonnes of leaf and yard waste was collected, both as mixed waste and source separated organics. The South Saskatchewan (51%) and the North Saskatchewan (38%) together accounting for about 90% of total leaf and yard waste. By 2040,

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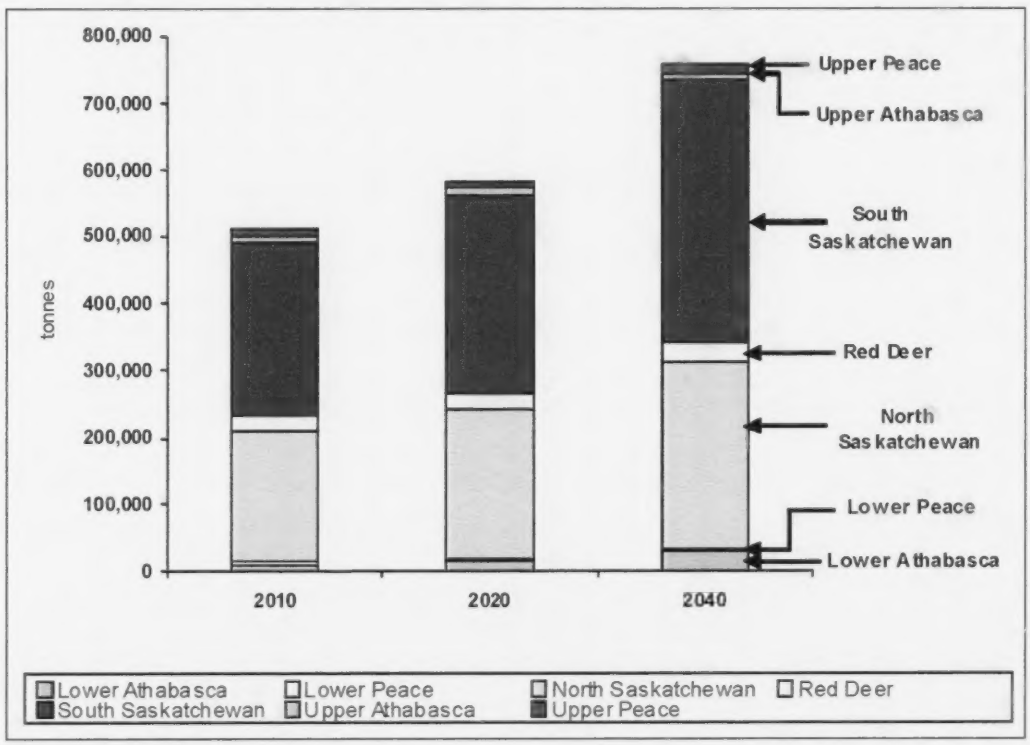
[20] Note this data is derived by multiplying the municipal unit specific per capita waste generation estimate with associated population numbers. Alberta Environment reports disposal of about 3 million tonnes in 2008 based on statistics collected by the Canadian Council of Ministers of the Environment and accounts for the effect of any existing waste diversion program on disposal.

about 750,000 tonnes of leaf and yard waste is expected with the South and the North Saskatchewan Regions together continuing to account for the most of that waste.

With the existing composting infrastructure approximately 125,000 tonnes of leaf and yard waste is composted (CH2MHill, 2010). The North Saskatchewan (79%), the Red Deer (7%) and the South Saskatchewan (10%) together account for almost all of the total leaf and yard waste composted in the province annually.

Figure 3-1 Projected Leaf and Yard Waste Collection by Region



3.2 Infrastructure Needs

The Feasibility Study identifies the costs of building centralized leaf and yard waste composting infrastructure throughout the province. Table 3-1 presents a summary of these costs, compared to this study's calculations of building centralized composting infrastructure to meet the modest and aggressive diversion targets. This information is to facilitate a comparison of estimated infrastructure costs from the two reports and understand any differences. Points to consider in this comparison include:

- Feasibility Study assessed potential capital cost for management of leaf and yard waste by recommending composting infrastructure for 120 communities[21] throughout the province, while this study examined costs for meeting diversion targets for communities collecting over 50 tonnes/year of leaf and yard waste. This study assigns no infrastructure costs for regions that are already meeting the diversion targets. This is indicated by 'NA' in the table cell.
- Feasibility Study included some collection infrastructure costs (e.g. development of a drop off/transfer site). Although these costs are small, about two percent of overall estimated costs for Alberta, this one of the causes for discrepancy between Feasibility Study costs and this study's costs.
- Feasibility Study provided costs as a one time expenditure, while this study calculates costs annually over the 2010 to 2040 periods. To facilitate comparison between the two costs, a ten year life span on the infrastructure was assumed. This required aggregating annual value derived in this study over the 2010 to 2020 period.
- Feasibility Study costs are presented as one time costs which are not amortized: there are no interest costs associated with the infrastructure cost expenditures. To facilitate comparison, this study also assumed no interest costs when calculating values for this table.

These considerations are applicable for Table 3-1 only, as rest of the benefits and costs information are presented as annual value, including accounting for interest costs amortized over life of composting infrastructure.

[21] Regional Infrastructure Development Requirements, Appendix C, "Leaf and Yard Waste Diversion Strategy Feasibility Study", CH2M Hill, 2010.

Table 3-1 Infrastructure Costs from Feasibility Study compared to Infrastructure Costs to Meet Diversion Targets

Region	Cost Reported in Feasibility Study	Cost of Meeting Modest Diversion Target	Cost of Meeting Aggressive Diversion Target
Lower Athabasca	$1,025,000	NA*	$54,381 (target unmet 2017-2020)
Lower Peace	$200,000	$14,364	$92,819
North Saskatchewan	$1,930,000	NA*	$2,571,128
Red Deer	$1,750,000	NA*	NA*
South Saskatchewan	$17,830,000	$11,269,884	$19,289,190
Upper Athabasca	$832,500	NA*	$404,561
Upper Peace	$887,500	$317,717	$659,562
Total	$24,455,000	$11,601,965	$23,071,641

*NA -current composting exceeds diversion target over the 2010-2020 period

3.3 Benefits and Costs of Diversion Targets

Table 3-2 shows the amount of leaf and yard waste that are expected to be collected from 2010 to 2040. Table 3-3 shows amounts diverted under modest and aggressive diversion targets. The amount of leaf and yard waste collected is expected to rise from approximately 500,000 tonnes in 2010 to 750,000 tonnes annually by 2040 (about 50% increase). This increase is due to population growth. Existing compost processing capacity is able to process approximately 25% of the materials collected; however, this proportion will decline to about 17% by 2040 without additional composting capacity. Under the aggressive diversion scenario approximately 55% of the collection is diverted while under modest diversion 35% of the collection is diverted. Managing that level of diversion will require expansion of current composting infrastructure capacity by about a third (modest diversion in 2010) to 2.5 times for aggressive diversion by 2040.

Table 3-2 Forecast of Leaf and Yard Waste Collection and Management for Alberta

	2010	2020	2040
Leaf and yard waste collected (t/y)	505,283	573,811	748,923
Current amount of LYW composted (t/y)	124,528	124,528	124,528
Diversion of LYW, based on BAU[22]	25%	22%	17%

Table 3-3 Compiled Diversion Targets for Leaf and Yard Waste Collected in Alberta

	2010	2020	2040
Modest (% diversion)	167,883 (33%)	194,317 (34%)	262,225 (35%)
Aggressive (% diversion)	281,897 (56%)	324,495 (57%)	433,797 (58%)

Tables 3-4 and 3-5 present the annual costs and benefits of meeting the modest diversion target. The cost of composting additional leaf and yard waste is estimated to range from $1.8 million in 2010 to $3.1 million by 2040. In comparison, landfilling is expected to cost $4.3 million in 2010 to $7.3 million by 2040. The avoided landfill benefit is estimated to range from $5.1 million in 2010 to $8.8 million by 2040. The value of additional compost produced ranges from $0.6 million to $1.3 million in 2010 and $1.0 million to $2.2 million by 2040. Achieving the modest diversion target leads to approximately 33 % reduction in greenhouse gases by 2040. The quantified annual net benefit of the modest diversion target is positive and ranges from $3.4 million to $4.1 million in 2010 to $6.0 million to $7.2 million by 2040.

Tables 3-6 and 3-7 present the annual costs and benefits of the aggressive diversion target. Composting costs are estimated to range from $4.3 million in 2010 to $8.0 million by 2040. In comparison, landfilling is expected to cost $14.5 million in 2010 to $27.8 million by 2040. On per unit basis, the average cost per tonne for composting was estimated to be about $27 while for landfill the cost was estimated to be about $90. The avoided landfill benefit is estimated to range from $10.1 million in 2010 to $19.8 million by 2040. The compost value ranges from $1.1 million to $2.4 million in 2010 and 2.2 million to $4.7 million by 2040. The aggressive diversion target results in up to about 70 % reduction in greenhouse gases by 2040. The quantified annual

[22] BAU refers to 'business as usual' - no change from current levels of leaf and yard waste composting. Current composting capacity is assumed to be fully utilized and remain unchanged for the duration of the forecast period.

net benefit of the aggressive diversion target is positive and ranges from $6.8 million to $8.1 million in 2010 to $14.0 million to $16.4 million by 2040.

Scenario 1: Meeting Modest Diversion Targets for Alberta

Table 3-4 Annual Costs of Leaf and Yard Waste Diversion to meet Modest Diversion Target

	2010	2020	2040
Additional LYW to be managed (t/y)	84,269	99,948	143,510
Composting cost[23] to compost additional LYW, million	$ 1.8 M	$ 2.1 M	$ 3.1 M
versus Landfill cost[24] to dispose of additional LYW, million	$ 4.3 M	$ 5.1 M	$ 7.3 M

Table 3-5 Annual Benefits of Leaf and Yard Waste Diversion to meet Modest Diversion Target

	2010	2020	2040
Avoided landfill cost, million	$ 4.3 M	$ 5.1 M	$ 7.3 M
Value of additional compost produced (assume $14 – 30/t), million	$ 0.6 – 1.3 M	$ 0.7 – 1.5 M	$ 1.0-2.2 M
Composting cost, million	$ 1.8 M	$ 2.1 M	$ 3.1 M
Net benefit, million[25]	$ 3.1 – 3.8 M	$ 3.7 – 4.5 M	$ 5.3 – 6.4 M
Percent change in GHG emissions, relative to BAU[26]	-19%	-23%	-33%
Quantity change in GHG emissions, relative to BAU (annual tonne CO_2 eq)	-109,083	-129,379	-185,767

[23] Some caution is warranted in reading this average cost. Note that this is an aggregate average for Alberta and masks region specific costs. Specific regional costs are presented in tables that accompany analysis of each region.

[24] *ibid*

[25] Net benefit = (Avoided Cost +Value of Additional Compost) - (Composting Cost)

[26] BAU refers to 'business as usual' - no change from current levels of leaf and yard waste composting. Current composting capacity is assumed to be fully utilized and remain unchanged for the duration of the forecast period.

Scenario 2: Meeting Aggressive Diversion Targets for Alberta

Table 3-6 Annual Costs of Leaf and Yard Waste Diversion to meet Aggressive Diversion Target

	2010	2020	2040
Additional LYW to be managed (t/y)	161,321	202,027	309,772
Composting cost[27] to compost additional LYW, million	$ 3.5 M	$ 4.3 M	$ 6.5 M
versus Landfill cost[28] to dispose of additional LYW, million	$ 8.1 M	$ 10.6 M	$ 15.8 M

Table 3-7 Annual Benefits of Leaf and Yard Waste Diversion to meet Aggressive Diversion Target

	2010	2020	2040
Avoided landfill cost, million	$ 8.1 M	$ 10.6 M	$ 15.8 M
Value of additional compost produced (assume $14 – 30/t), million	$ 1.1– 2.4 M	$ 1.4 – 3.0 M	$ 2.1 – 4.6 M
Composting cost, million	$ 3.5 M	$ 4.3 M	$ 6.5 M
Net benefit, million[29]	$ 8.8 – 7.1 M	$ 7.7 – 9.3 M	$ 11.4 – 13.9 M
Percent change in GHG emissions, relative to BAU[30]	-37%	-46%	-71%
Quantity change in GHG emissions, relative to BAU (t annual tonne CO_2 eq)	-208,823	-261,516	-400,987

[27] Some caution is warranted in reading this average cost. Note that this is an aggregate average for Alberta and masks region specific costs. Specific regional costs are presented in tables that accompany analysis of each region.

[28] *ibid*

[29] Net benefit = (Avoided Cost +Value of Additional Compost) - (Composting Cost)

[30] BAU refers to 'business as usual' - no change from current levels of leaf and yard waste composting. Current composting capacity is assumed to be fully utilized and remain unchanged for the duration of the forecast period.

4. Lower Athabasca

The Lower Athabasca Region is about 93,000 km2 with two main urban centres (Fort McMurray, City of Cold Lake) and 30 municipalities. The population is about 140,000 with about eighty percent of the population found in the two large urban centres of Cold Lake and the Regional Municipality of Wood Buffalo. The population of this region is expected to triple by 2040 compared to today as a result of population growth in the Regional Municipality of Wood Buffalo.

4.1 Waste Collection and Management

About 120,000 tonnes of municipal solid waste was collected in 2010, of which about 100,000 tonnes (86%) was expected to be landfilled.[31] Beginning around 2020, this proportion is expected to decline to about 60% with further declines to about 55% by 2040 as municipalities in the region undertake programs to divert waste away from landfills. The proportion of leaf and yard waste in the municipal solid waste stream is expected to be around eight percent over the forecast period.

The amount of leaf and yard waste collected annually is expected to triple from approximately 9,000 tonnes in 2010 to 28,000 tonnes by 2040. Currently about 60% (or approximately 5,300 tonnes) of the leaf and yard waste collection is composted. Table 4-1 shows the amount of leaf and yard waste that are expected to be collected and composted from 2010 to 2040 if there is no change in the current composting infrastructure for the region.

[31] Some oil sands operators send some of their waste to the regional landfill, however, this volume is small (less than 5% of the total waste being collected in the region) so oil sands waste is not included as part of waste data for this region. It is assumed that oil sands operators will continue to use their existing onsite landfills to dispose of their waste.

Table 4-1 Forecast of Leaf and Yard Waste to be Collected and Managed in the Lower Athabasca Region

	2010	2020	2040
Leaf and yard waste collected (t/y)	9,219	12,918	28,394
Baseline of LYW composted (t/y)	5,314	5,314	5,314
Diversion of LYW, based on BAU[32]	58%	41%	18%

The diversion targets for the region vary over time since the targets depend on the population and percentage of small, medium, and large urban centres. The modest target ranges from 25% to 33% diversion of leaf and yard waste collected for the region, while the aggressive target ranges from 44% to 55%. Table 4-2 shows the amounts of leaf and yard waste that need to be diverted to meet the modest and aggressive diversion targets.

Under the current level of leaf and yard waste diversion, the Lower Athabasca region exceeds modest diversion targets up to 2027. To meet the aggressive diversion target, additional composting capacity is required by 2017.

Table 4-2 Diversion Targets for Leaf and Yard Waste Collected in the Lower Athabasca Region

	2010	2020	2040
Modest (% diversion)	2,333 (25%)	3,691 (29%)	9,488 (33%)
Aggressive (% diversion)	4,068 (44%)	6,251 (48%)	15,485 (55%)

4.2 Benefits and Costs of Diversion Targets

Tables 4-3 and 4-4 present the annual costs and benefits of meeting the modest diversion target. By 2040, annual composting costs for managing the additional leaf and yard waste are an estimated $110,000 with an average cost of $ 27 per tonne. This is less than the anticipated landfilling cost of $180,000 at an average of $43 per tonne. The benefits of meeting the modest diversion target include a 91 % reduction in greenhouse gas emissions, $180,000 in avoided

[32] BAU refers to 'business as usual' - no change from current levels of leaf and yard waste composting. Current composting capacity is assumed to be fully utilized and remain unchanged for the duration of the forecast period.

landfill costs, and $30,000 to $64,000 worth of compost. The estimated annual net benefit of meeting the modest diversion target ranges from $97,000 to $130,000.

Results for the aggressive diversion target are presented in Table 4-5 for costs and Table 4-6 for benefits. The annual on-site composting cost is estimated to be $43,000 in 2020 and $21,000 in 2040, ranging from an average cost per tonne of $45 to $21. This variation is due to the higher cost per tonne for smaller facilities. The cost of landfilling the leaf and yard waste is expected to be about $437,000 at an average cost of $43 per tonne.

The calculated benefits of diverting enough leaf and yard waste to meet the aggressive diversion target by 2040 include a 223 % reduction in greenhouse gas emissions, $350,000 in avoided landfill costs and $71,000 to $150,000 of compost. The annual net benefit of the aggressive diversion target ranges from $4,600 - $12,000 in 2020 and $300,000 to $400,000 by 2040.

Scenario 1: Meeting Modest Diversion Targets in the Lower Athabasca Region

Table 4-3 Annual Costs of Leaf and Yard Waste Diversion to meet Modest Diversion Target

	2010	2020	2040
Additional LYW to be managed (t/y)	None- diversion meets target	None- diversion meets target	4,134
Composting cost to compost additional LYW versus			$110,000
Landfill cost to dispose of additional LYW			$180,000
Composting cost per tonne to compost additional LYW versus			$27
Landfill cost per tonne to dispose of additional LYW			$43

	2010	2020	2040
Avoided land fill cost	None- diversion meets target	None- diversion meets target	$180,000
Value of additional compost produced (assume $14 – 30/t)			$30,000 – $64,000
Composting cost, million			$110,000
Net benefit [33]			$97,000 – $131,000
Percent change in GHG emissions, relative to BAU[34]			-91%
Quantity change in GHG emissions, relative to BAU (annual tonne CO2eq)			-5,352

[33] Net Benefit = (Avoided Cost +Value of Additional Compost) - (Composting Cost)

[34] BAU refers to 'business as usual' - no change from current levels of leaf and yard waste composting. Current composting capacity is assumed to be fully utilized and remain unchanged for the duration of the forecast period.

Table 4-4 Annual Benefits of Leaf and Yard Waste Diversion to meet Modest Diversion Target

Scenario 2: Meeting Aggressive Diversion Targets in the Lower Athabasca Region

Table 4-5 Annual Costs of Leaf and Yard Waste Diversion to meet Aggressive Diversion Target

	2010	2020	2040
Excess LYW to be managed (t/y)	None- diversion meets target	937	10,171
Composting cost to compost additional LYW versus Landfill cost to dispose of additional LYW		$43,000	$214,000
		$40,000	$437,000
Composting cost per tonne to compost additional LYW versus Landfill cost per tonne to dispose of additional LYW		$45	$21
		$43	$43

Table 4-6 Annual Benefits of Leaf and Yard Composting to Meet Aggressive Diversion Target

	2010	2020	2040
Avoided landfill cost	None- diversion meets target	$43,000	$214,000
Value of additional compost produced (assume $14 – 30/t)		$6,500 - $14,000	$71,000 – $153,000
Composting cost		$43,000	$214,000
Net benefit [35]		$4,600 - $12,000	$294,000 – $376,000
Percent change in GHG emissions, relative to BAU[36]		-21%	-223%
Quantity change in GHG emissions, relative to BAU (annual tonne CO2eq)		-1,213	-13,165

[35] Net benefit = (Avoided Cost +Value of Additional Compost) - (Composting Cost)

[36] BAU refers to 'business as usual' - no change from current levels of leaf and yard waste composting. Current composting capacity is assumed to be fully utilized and remain unchanged for the duration of the forecast period.

5. Lower Peace

The Lower Peace Region is about 192,000 km^2 with 19 municipalities classified as small urban or rural. The population is about 41,000 with small urban centres accounting for just under half of the total population. Rural residents make up 54% of the population in this region. This population is not expected to change much compared to today.

5.1 Waste Collection and Management

About 65,000 tonnes of municipal solid waste was collected in 2010, of which about 51,000 tonnes (80%) was expected to be landfilled. This landfill proportion is expected to remain unchanged over the forecast period. The amount of leaf and yard waste collected is expected to rise from approximately 4,000 tonnes in 2010 to 4,500 tonnes annually by 2040. The proportion of leaf and yard waste in the municipal solid waste stream is expected to be around six percent over the forecast period. Currently none of the leaf and yard waste that is collected is composted. Table 5-1 shows the amount of leaf and yard waste that are expected to be collected from 2010 to 2040.

Table 5-1 Forecast of Leaf and Yard Waste to be Collected and Managed in the Lower Peace Region

	2010	2020	2040
Leaf and yard waste collected (t/y)	3,988	4,138	4,456
Baseline of LYW composted (t/y)	0	0	0
Diversion of LYW, based on BAU[37]	0%	0%	0%

The diversion targets for the region vary over time since the targets depend on the population and percentage of small, medium, and large urban centres. Table 5 2 shows the amounts of leaf and yard waste that need to be diverted to meet the modest and aggressive diversion targets.

[37] BAU refers to 'business as usual' - no change from current levels of leaf and yard waste composting. Current composting capacity is assumed to be fully utilized and remain unchanged for the duration of the forecast period.

The Lower Peace region currently does not have infrastructure capacity to handle the leaf and yard waste generated by the diversion targets.

Table 5-2 Diversion Targets for Leaf and Yard Waste Collected in the Lower Peace Region

	2010	2020	2040
Modest (% diversion)	52 (1%)	55 (1%)	62 (1%)
Aggressive (% diversion)	337 (8%)	355 (8%)	392 (9%)

5.2 Benefits and Costs of Diversion Targets

The costs and benefits of diverting enough leaf and yard waste to meet the modest diversion target are presented in Tables 5-3 and Table 5-4. The annual on-site composting infrastructure cost is expected to range from $3,892 in 2010 to $4,521 by 2040, with an average cost of $75 per tonne. Landfilling is expected to be less with an expected cost of $2,244 to $2,607 over the 2010 to 2040 period. This works out to an average cost of $43 per tonne. The total composting cost is higher than landfilling because for small composting facilities per tonne cost are higher than for landfilling.

By 2040, the benefits of diverting leaf and yard waste to composting include a one percent reduction in greenhouse gas emissions, $2,607 in avoided landfill costs and $400 to $900 worth of compost. The estimated annual net benefit of meeting the modest diversion target is negative, with values ranging from $ (1,300) to $(865) in 2010 and $(1,500) to $ (1,000) in 2040.

The costs and benefits of meeting the aggressive diversion target are presented in Table 5-5 and Table 5-6. The annual on-site composting infrastructure cost is expected to range from $25,000 in 2010 to $29,000 in 2040, at an average cost of $75 per tonne. The cost of disposing leaf and yard waste in a landfill is expected to range from $15,000 to $17,000 over the 2010 to 2040 period, at an average cost of $43 per tonne. By 2040, the benefits include nine percent reduction in greenhouse gas emissions, $17,000 in avoided landfill costs and a small compost value. The estimated annual net benefit of the aggressive diversion target is negative, with values ranging from $(8,300) to $ (5,600) in 2010 and $ (9,600) to $(6,500) in 2040.

Scenario 1: Meeting Modest Diversion Targets in the Lower Peace Region

Table 5-3 Annual Costs of Leaf and Yard Waste Diversion to meet Modest Diversion Target

	2010	2020	2040
Additional LYW to be managed (t/y)	52	55	62
Composting cost to compost additional LYW versus Landfill cost to dispose of additional LYW	$3,892 $2,244	$4,091 $2,359	$4,521 $2,607
Composting cost per tonne to compost additional LYW versus Landfill cost per tonne to dispose of additional LYW	$75 $43	$75 $43	$75 $43

Table 5-4 Annual Benefits of Leaf and Yard Waste Diversion to meet Modest Diversion Target

	2010	2020	2040
Avoided landfill cost	$2,244	$2,359	$2,607
Value of additional compost produced (assume $14 – 30/t)	$365 -783	$384 - 823	$424 - 909
Composting cost	$3,892	$4,091	$4,521
Net benefit [38]	$ (1,300) – (865)	$ (1,350) – (900)	$(1,500) – ($1,000)
Percent change in GHG emissions, relative to BAU[39]	-1%	-1%	-1%
Quantity change in GHG emissions, relative to BAU (annual tonne, CO2 eq)	-68	-71	-78

[38] Net benefit = (Avoided Cost +Value of Additional Compost) - (Composting Cost). Values in brackets denote negative numbers.

[39] BAU refers to 'business as usual' - no change from current levels of leaf and yard waste composting. Current composting capacity is assumed to be fully utilized and remain unchanged for the duration of the forecast period.

Scenario 2: Meeting Aggressive Diversion Targets in the Lower Peace Region

Table 5-5 Annual Costs of Leaf and Yard Waste Diversion to meet Aggressive Diversion Target

	2010	2020	2040
Additional LYW to be managed (t/y)	337	355	392
Composting cost to compost additional LYW	$25,000	$26,000	$29,000
versus			
Landfill cost to dispose of additional LYW	$15,000	$15,000	$17,000
Composting cost per tonne to compost additional LYW	$75	$75	$75
versus			
Landfill cost per tonne to dispose of additional LYW	$43	$43	$43

Table 5-6 Annual Benefits of Leaf and Yard Waste Diversion to meet Aggressive Diversion Target

	2010	2020	2040
Avoided landfill cost	$15,000	$15,000	$17,000
Value of additional compost produced (assume $14 – 30/t)	$2,300 - 5,000	$2,500 - 5,300	$2,700– 5,900
Composting cost	$25,000	$26,000	$29,000
Net benefit [40]	$(8,300) – (5,600)	$(8,700) – (5,800)	$ (9,600) – (6,500)
Percent change in GHG emissions, relative to BAU[41]	-7%	-8%	-9%
Quantity change in GHG emissions, relative to BAU (annual tonne, CO2 eq)	-437	-459	-507

[40] Net benefit = Avoided Cost - Composting Cost + Value of Additional Compost. Values in brackets denote negative numbers

[41] BAU refers to 'business as usual' - no change from current levels of leaf and yard waste composting. Current composting capacity is assumed to be fully utilized and remain unchanged for the duration of the forecast period.

6. North Saskatchewan

The North Saskatchewan Region is about 86,000 km^2 with about 1.3 million people located in 127 municipalities. Approximately half of the population lives in Edmonton, the largest population centre. The urban areas classified as metro, large urban, and small urban account for about 85 percent of this region's population. Compared to today, this region's population is expected to increase by 40 percent by 2040 with most of this increase occurring in urban areas.

6.1 Waste Collection and Management

About 1.7 million tonnes of municipal solid waste was collected in 2010, of which about 900,000 tonnes (54%) was expected to be landfilled. Beginning around 2015, this proportion is expected to decline to about 35% with further declines to about 30% by 2040 as municipalities in the region undertake programs to divert waste away from landfills. The amount of leaf and yard waste collected is expected to rise from approximately 190,000 tonnes in 2010 to 270,000 tonnes annually by 2040. The proportion of leaf and yard waste in the municipal solid waste stream is expected to be around eight percent over the forecast period. Currently about 50% (or approximately 98,000 tonnes) of the leaf and yard waste collection is composted. Table 6-1 shows the amount of leaf and yard waste that are expected to be collected from 2010 to 2040. The City of Edmonton collects mixed municipal solid waste, including leaf and yard waste, for composting. This large program skews the leaf and yard waste composting data for the North Saskatchewan region. It is recommended that the North Saskatchewan region is further examined for opportunities to expand leaf and yard waste diversion in the communities surrounding the City of Edmonton.

Table 6-1 1 Forecast of Leaf and Yard Waste to be Collected and Managed in the North Saskatchewan Region

	2010	2020	2040
Leaf and yard waste collected (t/y)	198,675	215,915	271,873
LYW composted (t/y)	98,259	98,259	98,259
Diversion of LYW, based on BAU[42]	51%	46%	36%

The diversion targets for the region vary over time since the targets depend on the population and percentage of small, medium, and large urban centres. Table 6-2 shows the amounts of leaf and yard waste to be diverted under modest and aggressive diversion targets. Under the current level of diversion, the North Saskatchewan Region exceeds modest diversion targets for the entire forecast period. The current level of diversion is insufficient to meet the aggressive diversion target for all forecast years. The benefit cost assessment is reported for aggressive diversion target only.

Table 6-2 Diversion Targets for Leaf and Yard Waste Collected in North Saskatchewan Region

	2010	2020	2040
Modest (% diversion)	67,103 (35%)	76,130 (35%)	97,957 (36%)
Aggressive (% diversion)	112,280 (58%)	126,792 (59%)	161,863 (60%)

6.2 Benefits and Costs of Diversion Targets

The costs and benefits of managing the additional leaf and yard waste to meet the aggressive diversion target are presented in Table 6-3 and Table 6-4. The annual onsite composting infrastructure cost is expected to range from $0.3 million in 2010 to $1.2 million in 2040, with the average cost ranging from $19 to $21 per tonne. Landfilling the additional material is expected to range from $0.6 million to $3.3 million over the 2010 to 2040 period at an average cost ranging from $43 to $62 per tonne. By 2040, the benefits include a 55% reduction in greenhouse gas emissions, $3.3 million in avoided landfill costs and compost value ranging from $0.45 million to $0.96 million. The estimated annual net benefit of the aggressive diversion

[42] BAU refers to 'business as usual' - no change from current levels of leaf and yard waste composting. Current composting capacity is assumed to be fully utilized and remain unchanged for the duration of the forecast period.

target is positive, with values ranging from $ 0.4 million to $ 0.5 million in 2010 and $ 2.5 million to $ 3.0 million in 2040.

Scenario 2: Meeting Aggressive Diversion Targets in the North Saskatchewan Region

Table 6-3 Annual Costs of Leaf and Yard Waste Diversion to meet Aggressive Diversion Target

	2010	2020	2040
Additional LYW to be managed (t/y)	14,021	28,533	63,604
Composting cost to compost additional LYW versus Landfill cost to dispose of additional LYW	$0.3 M	$0.5 M	$1.2 M
	$0.6 M	$1.8 M	$3.3 M
Composting cost per tonne to compost additional LYW versus Landfill cost per tonne to dispose of additional LYW	$21	$19	$19
	$43	$ 62	$ 51

Table 6-4 Annual Benefits of Leaf and Yard Waste Diversion to meet Aggressive Diversion Target

	2010	2020	2040
Avoided landfill cost	$0.6 M	$1.8 M	$3.3 M
Value of additional compost produced (assume $14 – 30/t)	$0.098 – 0.21 M	$0.2 – 0.4 M	$0.45 – 0.96 M
Composting cost	$0.3 M	$0.5 M	$1.2 M
Net benefit [43]	$0.4 – 0.5 M	$1.4 – 1.7 M	$2.5 – 3.0 M
Percent change in GHG emissions, relative to BAU[44]	-12%	-25%	-55%
Quantity change in GHG emissions, relative to BAU (annual tonne, CO_2 eq)	-18,149	-36,935	-82,322

[43] Net benefit = (Avoided Cost +Value of Additional Compost) - (Composting Cost).

[44] BAU refers to 'business as usual' - no change from current levels of leaf and yard waste composting. Current composting capacity is assumed to be fully utilized and remain unchanged for the duration of the forecast period.

7. Red Deer

The Red Deer Region is about 5,000 km^2 with about 300,000 people spread across 71 municipalities. The population is spread about a third each in large urban, small urban, and rural municipalities. The largest population centre is the City of Red Deer which accounts for nearly all of the large urban population. The population of this region is expected to increase by 1.3 times by 2040 compared to today.

7.1 Waste Collection and Management

About 355,000 tonnes of municipal solid waste is expected to be collected in 2010, of which about 80% is expected to be landfilled. This proportion is expected to remain unchanged for the duration of the forecast period. The amount of leaf and yard waste collected is expected to rise from approximately 21,000 tonnes in 2010 to 26,000 tonnes annually by 2040. The proportion of leaf and yard waste in the municipal solid waste stream is expected to be around six percent over the forecast period.

Currently about 40% (or approximately 8,800 tonnes) of leaf and yard waste collected is composted. Table 7-1 shows the amount of leaf and yard waste that are expected to be collected from 2010 to 2040. The City of Red Deer's residential leaf and yard waste composting program skews the data for the region.

Table 7-1 Forecast of Leaf and Yard Waste to be Collected and Managed in the Red Deer Region

	2010	2020	2040
Leaf and yard waste collected (t/y)	21,632	23,129	26,606
Baseline of LYW composted (t/y)	8,800	8,800	8,800
Diversion of LYW, based on BAU[45]	41%	38%	36%

Table 7-2 shows the amounts of leaf and yard waste that must be collected and managed to meet the diversion targets for the Red Deer Region. This region meets both the modest and

[45] BAU refers to 'business as usual' - no change from current levels of leaf and yard waste composting. Current composting capacity is assumed to be fully utilized and remain unchanged for the duration of the forecast period.

aggressive diversion targets from 2010 to 2040 by continuing to compost at current 'business as usual' levels. Thus, the benefits and costs of meeting the diversion targets for this region are not estimated. It is recommended that the Red Deer region is further examined for opportunities to expand leaf and yard waste diversion in the communities surrounding the City of Red Deer.

Table 7-2 Diversion Targets for Leaf and Yard Waste Collected in Red Deer Region

	2010	**2020**	**2040**
Modest (% diversion)	2,207(10%)	2,562 (11%)	3,431 (13%)
Aggressive (% diversion)	5,882 (27%)	6,528 (28%)	8,086 (30%)

8. South Saskatchewan

The South Saskatchewan Region is about 83,000 km^2 with about 1.5 million people located in 85 municipalities. Approximately two thirds of the population lives in Calgary, the largest population centre. The urban areas (metro, large urban, small urban) collectively account for about 90 percent of this region's population. Compared to today, this region's population is expected to increase by 1.5 times by 2040 with most of this increase occurring in urban areas.

8.1 Waste Collection and Management

About 1.9 million tonnes of municipal solid waste is expected to be collected in 2010, of which about 80% is expected to be landfilled; this proportion is expected to decline to about 30% by 2040 as municipalities in the region undertake programs to divert waste away from landfills. Leaf and yard waste makes up about fourteen percent of the municipal solid waste that is collected in the region annually. This proportion is not expected to change considerably for the forecast period. Currently about five percent, or approximately 12,000 tonnes, of the leaf and yard waste collected is composted. Table 8-1 shows the amount of leaf and yard waste that are expected to be collected from 2010 to 2040.

Table 8-1 Forecast of Leaf and Yard Waste Collected and Managed in the South Saskatchewan Region

	2010	2020	2040
Leaf and yard waste collected (t/y)	260,784	296,033	393,560
Baseline of LYW composted (t/y)	12,043	12,043	12,043
Diversion of LYW, based on BAU[46]	5%	4%	3%

Table 8-2 shows the amounts diverted under modest and aggressive diversion targets. Under current conditions, the South Saskatchewan region does not meet the either of diversion targets

[46] BAU refers to 'business as usual' - no change from current levels of leaf and yard waste composting. Current composting capacity is assumed to be fully utilized and remain unchanged for the duration of the forecast period.

for the forecast period. Additional composting infrastructure is required to process the leaf and yard waste resulting from diversion targets.

Table 8-2 Diversion Targets for Leaf and Yard Waste Collected in the South Saskatchewan Region

	2010	2020	2040
Modest (% diversion)	95,389 (37%)	110,918 (37%)	149,980 (38%)
Aggressive (% diversion)	155,509 (60%)	180,422 (61%)	243,065 (62%)

8.2 Benefits and Costs of Diversion Targets

Tables 8-3 and 8-4 present the annual costs and benefits of meeting the modest diversion target. The composting cost is estimated to range from $1.7 million in 2010 to $2.9 million by 2040. In comparison, landfilling is expected to cost $4.2 million in 2010 to $7.1 million by 2040. On per unit basis, the average cost per tonne for composting was estimated to be $21 while for landfill the cost was estimated to be about $51. The compost value ranges from $0.6 million to $1.3 million in 2010 and $1.0 million to $2.2 million by 2040. The modest diversion target results in up to about 51% reduction in greenhouse gases by 2040. The quantified annual net benefit of the modest diversion target is positive and ranges from $3.1 million to $3.8 million in 2010 to $5.2 million to $6.3 million by 2040.

Results for the aggressive diversion target are presented in Tables 8-5 and Table 8-6. The annual onsite compost cost is estimated to be $3.1 million in 2010 and $4.9 million in 2040. In comparison, landfilling is expected to cost $7.3 million in 2010 to $11.9.0 million by 2040. On per unit basis, the average cost per tonne for composting was estimated to be about $21 while for landfill the cost was estimated to be about $51. The compost value ranges from $1.1 million to $2.2 million in 2010 and $1.6 million to $3.5 million by 2040. The aggressive diversion target results in up to 85% reduction in greenhouse gases by 2040. The quantified annual net benefit of the aggressive diversion target is positive and ranges from $5.3 million to $6.5 million in 2010 to $8.6 million to $10.5 million by 2040.

Scenario 1: Meeting Modest Diversion Target in the South Saskatchewan Region

Table 8-3 Annual Costs of Leaf and Yard Waste Diversion to meet Modest Diversion Target

	2010	2020	2040
Additional LYW to be managed (t/y)	83,346	98,875	137,937
Composting cost to compost additional LYW versus	$1.7 M	$2.0 M	$2.9 M
Landfill cost to dispose of additional LYW	$4.3 M	$5.0 M	$7.1 M
Composting cost per tonne to compost additional LYW versus	$21	$21	$21
Landfill cost per tonne to dispose of additional LYW	$51	$51	$51

Table 8-4 Annual Benefits of Leaf and Yard Waste Diversion to meet Modest Diversion Target

	2010	2020	2040
Avoided landfill cost	$4.3 M	$5.0 M	$7.1 M
Value of additional compost produced (assume $14 – 30/t)	$0.6 – 1.3 M	$0.7 – 1.5 M	$0.97 – 2.1 M
Composting cost	$1.7 M	$2.0 M	$2.9 M
Net benefit [47]	$3.1 – 3.8 M	$3.7 – 4.5 M	$5.2 -6.3 M
Percent change in GHG emissions, relative to BAU[48]	-31%	-36%	-51%
Quantity change in GHG emissions, relative to BAU (annual tonne, CO2 eq)	-107,888	-127,989	-178,554

[47] Net benefit = (Avoided Cost +Value of Additional Compost) - (Composting Cost).

[48] BAU refers to 'business as usual' - no change from current levels of leaf and yard waste composting. Current composting capacity is assumed to be fully utilized and remain unchanged for the duration of the forecast period.

Scenario 2: Meeting Aggressive Diversion Target in the South Saskatchewan Region

Table 8-5 Annual Costs of Leaf and Yard Waste Diversion to meet Aggressive Diversion Target

	2010	2020	2040
Additional LYW to be managed (t/y)	143,466	168,379	231,023
Composting cost to compost additional LYW	$3.0 M	$3.5 M	$4.9 M
versus			
Landfill cost to dispose of additional LYW	$7.3 M	$8.7 M	$11.9 M
Composting cost per tonne to compost additional LYW	$21	$21	$21
versus			
Landfill cost per tonne to dispose of additional LYW	$51	$51	$51

Table 8-6 Annual Benefits of Leaf and Yard Waste Diversion to meet Aggressive Diversion Target

	2010	2020	2040
Avoided landfill cost	$7.3 M	$8.7 M	$11.9 M
Value of additional compost produced (assume $14 – 30/t)	$1.0 – 2.2 M	$1.2 – 2.5 M	$1.6 – 3.5 M
Composting cost	$3.0 M	$3.5 M	$4.9 M
Net benefit [49]	$5.3 – 6.5 M	$6.3 – 7.6 M	$8.6 – 10.5 M
Change in GHG emissions, relative to BAU[50]	-53%	-62%	-85%
Net change in GHG emissions, relative to BAU (annual tonne, CO2 eq)	-185,711	-217,959	-299,049

[49] Net benefit = (Avoided Cost +Value of Additional Compost) - (Composting Cost).

[50] BAU refers to 'business as usual' - no change from current levels of leaf and yard waste composting. Current composting capacity is assumed to be fully utilized and remain unchanged for the duration of the forecast period.

9. Upper Athabasca

The Upper Athabasca Region is about 83,000 km^2 with about 120,000 people located in 53 municipalities. Approximately half of the population live in small urban centres the largest of which are Whitecourt, Edson and Hinton. The population of this region is not expected to change much over the forecast period compared to today.

9.1 Waste Collection and Management

About 210,000 tonnes of municipal solid waste is expected to be collected in 2010, of which about 80% is expected to be landfilled; this proportion is expected to remain unchanged over the forecast period. Leaf and yard waste makes up about five percent of the municipal solid waste that is collected in the region annually. This proportion is not expected to change considerably over forecast period.

Currently about 3% (or approximately 300 tonnes) of the leaf and yard waste collection is composted. Table 9-1 shows the amount of leaf and yard waste that are expected to be collected from 2010 to 2040.

Table 9-1 Forecast of Leaf and Yard Waste Collected and Managed in the Upper Athabasca Region

	2010	2020	2040
Leaf and yard waste collected (t/y)	11,033	11,462	12,374
LYW composted (t/y)	324	324	324
Diversion of LYW, based on BAU[51]	3%	3%	3%

Table 9-2 shows the amounts of leaf and yard waste that need to be diverted to meet the modest and aggressive diversion targets. Under the current level of diversion, the Upper Athabasca Region meets modest diversion targets for the entire forecast period. However, current level of diversion is insufficient to meet the aggressive diversion target for all forecast years. The benefit cost assessment is reported for aggressive diversion target only.

[51] BAU refers to 'business as usual' - no change from current levels of leaf and yard waste composting. Current composting capacity is assumed to be fully utilized and remain unchanged for the duration of the forecast period.

Table 9-2 Diversion Targets for Leaf and Yard Waste Collected in the Upper Athabasca Region

	2010	2020	2040
Modest (% diversion)	283 (3%)	297 (3%)	329 (3%)
Aggressive (% diversion)	1,751 (16%)	1,840 (16%)	2,033 (16%)

9.2 Benefits and Costs of Diversion Targets

Table 9-3 and 9-4 present the annual costs and benefits of meeting the aggressive diversion target. The annual onsite compost cost is estimated to be $64,300 in 2010 and $77,000 in 2040. In comparison, landfilling is expected to cost $61,300 in 2010 to $73,500 by 2040. On per unit basis, the average cost per tonne for composting was estimated to be about $45 while for landfill the cost was estimated to be about $43. There is a small compost value, up to $26,000 by 2040. The aggressive diversion target results in up to about 14% reduction in greenhouse gases by 2040. The quantified annual net benefit of the aggressive diversion target is positive and ranges from $7,000 to $18,500 in 2010 to $8,400 to $22,100 by 2040.

Scenario 2: Meeting Aggressive Diversion Target in the Upper Athabasca Region

Table 9-3 Annual Costs of Leaf and Yard Waste Diversion to Meet Aggressive Diversion Target

	2010	2020	2040
Additional LYW to be managed (t/y)	1,427	1,516	1,709
Composting cost to compost additional LYW versus	$64,300	$68,300	$77,000
Landfill cost to dispose of additional LYW	$61,300	$65,200	$73,500
Composting cost per tonne to compost additional LYW versus	$45	$45	$45
Landfill cost per tonne to dispose of additional LYW	$43	$43	$43

Table 9-4 Annual Benefits of Leaf and Yard Waste Diversion to Meet Aggressive Diversion Target

	2010	2020	2040
Avoided landfill cost	$61,300	$65,200	$73,500
Value of additional compost produced (assume $14 – 30/t)	$10,000 – 21,000	$11,000 – 23,000	$12,000 – 26,000
Composting cost	$64,300	$68,300	$77,000
Net benefit [52]	$7,000 – 18,500	$7,500 – 19,600	$8,500 – 22,100
Percent change in GHG emissions, relative to BAU[53]	-12%	-12%	-14%
Quantity change in GHG emissions, relative to BAU (annual tonne, CO2 eq)	-1,847	-1,963	-2,213

[52] Net benefit = (Avoided Cost +Value of Additional Compost) - (Composting Cost).

[53] BAU refers to 'business as usual' - no change from current levels of leaf and yard waste composting. Current composting capacity is assumed to be fully utilized and remain unchanged for the duration of the forecast period.

10. Upper Peace

The Upper Peace Region is about 74,000 km^2 with about 120,000 people located in 32 municipalities. Approximately 40 percent of the population lives in the large urban centre of Grande Prairie with another third living in small urban centres. The population of this region is expected to increase by about 25% by 2040.

10.1 Waste Collection and Management

About 93,000 tonnes of municipal solid waste is expected to be collected in 2010, of which about 85% is expected to be landfilled; this proportion is expected to remain essentially unchanged over the forecast period. Leaf and yard waste makes up about ten percent of the municipal solid waste that is collected in the region annually. This proportion is not expected to change considerably over forecast period.

Currently this region has no capacity dedicated for leaf and yard waste composting, therefore, composting infrastructure is required to process the waste collected from the diversion targets. Table 10-1 shows the amount of leaf and yard waste that are expected to be collected from 2010 to 2040.

Table 10-1 Forecast of Leaf and Yard Waste to be Collected and Managed in the Upper Peace Region

	2010	2020	2040
Leaf and yard waste collected (t/y)	9,586	10,216	11,659
Baseline of LYW composted (t/y)	0	0	0
Diversion of LYW, based on BAU[54]	0%	0%	0%

The diversion targets for the region vary over time since the targets depend on the population and percentage of small, medium, and large urban centres. Table 10-2 shows the amounts of leaf and yard waste to be diverted under modest and aggressive diversion targets.

[54] BAU refers to 'business as usual' - no change from current levels of leaf and yard waste composting. Current composting capacity is assumed to be fully utilized and remain unchanged for the duration of the forecast period.

Table 10-2 Diversion Targets for Leaf and Yard Waste Collected in the Upper Peace Region

	2010	2020	2040
Modest (% diversion)	871 (9%)	1,018 (10%)	1,373 (12%)
Aggressive (% diversion)	2,069 (22%)	2,307 (23%)	2,874 (25%)

10.2 Benefits and Costs of Diversion Targets

Tables 10-3 and 10-4 present the annual costs and benefits of the modest diversion target. The composting cost is estimated to range from $39,200 in 2010 to $61,800 by 2040. In comparison, landfilling is expected to cost $37,400 in 2010 to $59,000 by 2040. On per unit basis, the average cost per tonne for composting was estimated to be about $45 while for landfill the cost was estimated to be about $43. There is a small compost value of up to $25,000 by 2040. The modest diversion target results in up to about 13 percent reduction in greenhouse gases by 2040. The quantified annual net benefit of the modest diversion target is positive and ranges from $6,400 to $15,700 in 2010 to $8,900 to 22,200 by 2040.

Results for the aggressive diversion target are presented in Tables 10-5 and 10-6. The annual onsite compost cost is estimated to be $93,200 in 2010 and $130,000 in 2040. In comparison, landfilling is expected to cost $89,000 in 2010 to $123,600 by 2040. On per unit basis, the average cost per tonne for composting was estimated to be about $45 while for landfill the cost was estimated to be about $43. The compost value ranges from $14,500 to $31,000 in 2010 and $20,100 to $43,100 by 2040. The aggressive diversion target results in up to about 27 percent reduction in greenhouse gases by 2040. The quantified annual net benefit of the aggressive diversion target is positive and ranges from $10,200 to $26,700 in 2010 to $14,200 to $37,200 by 2040.

Scenario 1: Meeting Modest Diversion Target in the Upper Peace Region

Table 10-3 3 Annual Costs of Leaf and Yard Waste Diversion to Meet Modest Diversion Target

	2010	2020	2040
Additional LYW to be managed (t/y)	871	1,018	1,373
Composting cost to compost additional LYW versus	$39,200	$46,000	$61,800
Landfill cost to dispose of additional LYW	$37,400	$43,800	$59,000
Composting cost per tonne to compost additional LYW versus	$45	$45	$45
Landfill cost per tonne to dispose of additional LYW	$43	$43	$43

Table 10-4 Annual Benefits of Leaf and Yard Waste Diversion to Meet Modest Diversion Target

	2010	2020	2040
Avoided landfill cost	$37,400	$43,800	$61,000
Value of additional compost produced (assume $14 – 30/t)	$8,100 – 17,500	$9,200 – 19,700	$11,700 – 25,000
Composting cost	$39,200	$46,000	$61,800
Net benefit [55]	$6,400 – 15,700	$7,100 – 17,600	$8,900 – 22,200
Percent change in GHG emissions, relative to BAU[56]	-8%	-9%	-13%
Quantity change in GHG emissions, relative to BAU (annual tonne, CO2 eq)	-1,127	-1,319	-1,777

[55] Net benefit = (Avoided Cost +Value of Additional Compost) - (Composting Cost).

[56] BAU refers to 'business as usual' - no change from current levels of leaf and yard waste composting. Current composting capacity is assumed to be fully utilized and remain unchanged for the duration of the forecast period.

Scenario 2: Meeting Aggressive Diversion Target in the Upper Peace Region

Table 10-5 Annual Costs of Leaf and Yard Waste Diversion to Meet Aggressive Diversion Target

	2010	2020	2040
Additional LYW to be managed (t/y)	2,069	2,307	2,874
Composting cost to compost additional LYW	$93,200	$104,000	$130,000
versus			
Landfill cost to dispose of additional LYW	$89,000	$99,200	$123,600
Composting cost per tonne to compost additional LYW	$45	$45	$45
versus			
Landfill cost per tonne to dispose of additional LYW	$43	$43	$43

Table 10-6 Annual Benefits of Leaf and Yard Waste Diversion to Meet Aggressive Diversion Target

	2010	2020	2040
Avoided landfill cost	$89,000	$99,200	$123,600
Value of additional compost produced (assume $14 – 30/t)	$14,500 – 31,000	$16,100 – 34,600	$20,100 – 43,100
Composting cost	$93,200	$104,000	$130,000
Net benefit [57]	$10,200 – 26,700	$11,400 – 29,800	$14,200 – 37,200
Percent change in GHG emissions, relative to BAU[58]	-19%	-21%	-27%
Quantity change in GHG emissions, relative to BAU (annual tonne, CO_2 eq)	-2,679	-2,987	-3,721

[57] Net benefit = (Avoided Cost +Value of Additional Compost) - (Composting Cost).

[58] BAU refers to 'business as usual' - no change from current levels of leaf and yard waste composting. Current composting capacity is assumed to be fully utilized and remain unchanged for the duration of the forecast period.

11. Conclusion

About 500,000 t of leaf and yard waste is collected annually in the province of Alberta and is sent for disposal in landfills or for recycling in composting facilities. This amount is expected to increase to 750,000 t per year by 2040.

Leaf and yard waste collected in 2010 varied throughout the province, from an estimated 4000 t in the Lower Peace region to 260,000 t in the South Saskatchewan region. This regional variability indicates a need to develop a provincial approach that can accommodate individual communities.

Some regions already have strong leaf and yard waste management programs that skew the data for the entire area. Examining individual communities within the regions will show variation not apparent from the data presented in this report. For example, the Red Deer region shows great success with composting leaf and yard waste and is meeting the recommended diversion targets and this is largely due to the City of Red Deer's leaf and yard waste diversion program. The same is true of the North Saskatchewan region, due to the City of Edmonton's composting program. Further analysis of the regions will clarify which communities could benefit from adopting leaf and yard waste diversion programs.

On the other hand, obvious deficits in leaf and yard waste composting can overshadow successful programs in the region. This report shows the South Saskatchewan region overall has a significant shortage in leaf and yard waste composting infrastructure. The City of Medicine Hat's successful composting program is not apparent without a more detailed examination of the South Saskatchewan region.

Meeting the diversion targets in this report is an excellent first step, but opportunities still abound for recycling organics into value added products. The recommended diversion targets are only for residential leaf and yard waste. Communities that meet these diversion targets are poised to expand their organics recycling programs to include food scraps and organics from the industrial, commercial, and institutional sectors.

A leaf and yard waste diversion program for Alberta needs to acknowledge the varying amounts generated and the diversity of composting programs throughout the province. Any recommended diversion program should provide options to help establish new leaf and yard recycling programs while allowing early adopters to continue leading the way. Expanding composting throughout Alberta to recycle organics such as leaf and yard

waste will create a valuable soil amendment and decrease greenhouse gas emissions throughout the province.

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Appendix A

Table 1 Original Data from MSW (2006).

		Community Size		
	Units	20,000	80,000	200,000
Land fill Size	ha	8.4	18.2	34.4
Total Capacity	tonne	293,580	1,150,424	2,935,802
1. Pre-development Cost				
a. Site Selection Allowance	lump sum ($)	250,000	500,000	750,000
b. Land Acquisition Allowance	$/ha	150,000	350,000	350,000
c. Approvals Allowance	lump sum ($)	3,000,000	5,000,000	5,000,000
2. Site Development (Capital Works)				
a. Site Clearing and Preparation	$/ha	10,000	10,000	10,000
b. Utilities Allowance	lump sum ($)	150,000	150,000	150,000
c. Site Infrastructure Allowance	$/ha	75,000	75,000	75,000
d. Cell Excavation and Base Preparation	$/m^2	100	135	135
e. Engineered Leachate Containment and Collection System	$/m^2	0	75	75

		Community Size		
	Units	20,000	80,000	200,000
f. Leachate Recirculation System	$/m^2	0	1	1
g. LFG Collection and Flaring System	$/m^2	0	1	1
h. Cap System Construction	$/m^2	30	30	30
i. Environmental Monitoring Infrastructure Allowance	lump sum($)	150,000	200,000	250,000
3. Site Operations				
a. Administration and Support Staff	$/yr	50,000	100,000	250,000
b. Waste Disposal Operations	$/$m^3$	8	10	10
c. Daily Cover Placement	$/$m^3$	5	8	8
d. Leachate Treatment	$/$m^3$	0	5	5
e. Reporting	$/yr	20,000	40,000	100,000
4. Post-Closure Management				
a. Staffing and Administration	$/yr	10,000	20,000	50,000
b. Leachate Treatment	$/yr	0	255,000	520,000
c. Maintenance Allowance	$/yr	10,000	40,000	100,000

Table 2 MSW (2006) Updated Cost

Community size	Units	20,000	80,000	200,000
Land fill Size	ha	8.4	18.2	34.4
Total Capacity	tonne	293,580	1,150,424	2,935,802
1. Site Development (Capital Works)				
a. Site Clearing and Preparation	total cost	97,589	211,559	399,651
b. Utilities Allowance	lump sum	174,266	174,266	174,266
c. Site Infrastructure Allowance	total cost	731,919	1,586,696	2,997,383
d. Cell Excavation and Base Preparation	total cost	683,125	1,480,916	2,797,557
e. Engineered Leachate Containment and Collection System	total cost	0	15,866,961	29,973,830
f. Leachate Recirculation System	total cost	0	211,559	399,651
g. Cap System Construction	total cost	2,927,676	6,346,784	11,989,532
h. Environmental Monitoring Infrastructure Allowance	lump sum	174,266	232,355	290,444
2. Site Operations				
a. Administration and Support Staff	total cost	1,161,776	2,323,553	5,808,882
b. Waste Disposal Operations	total cost	1,819,063	8,910,236	22,738,303

Community size	Units	20,000	80,000	200,000
c. Daily Cover Placement	total cost	1,136,914	7,128,189	18,190,642
d. Leachate Treatment	total cost	0	4,455,118	11,369,151
e. Reporting	total cost	464,711	929,421	2,323,553
3. Post-Closure Management		0	0	0
a. Staffing and Administration	lump sum	11,618	23,236	58,089
b. Leachate Treatment	lump sum	0	296,253	604,124
c. Maintenance Allowance	lump sum	11,618	46,471	116,178

Notes on updated cost data:

1. 1.5 m^3 of waste converted to 1 tonne of waste. Densities are site specific and can range from 600 kg/m^3 of compacted waste at small landfills to 850 kg/m^3 for large landfills.
2. Pre-development costs are removed as these costs can be site specific.
3. Cell excavation and base preparation cost have been revised to $7/m2 from the original value when deriving the updated cost data. The original values were considered to be high relative to cost in the literature. The revised cost is consistent with Alberta Environment and Sustainable Resource Development landfill closure and post closure cost calculation template.
4. Landfill gas cost is removed as this is not a common practice in Alberta.
5. 2006 cost inflated to 2010 cost using Statistics Canada price index for non-residential building construction. 2006 = 126.1; 2010 = 146.5

6. Based on review of cost allowances for Alberta Environment and Sustainable Resource Development's landfill security calculation, post closure cost in the MSW (2006) report is assumed to be lump sum, not annual cost as reported.